

2.2.7 Human Factors

The importance of human factors in the design of voting systems has become increasingly apparent. It is not sufficient that the internal operation of these systems be correct; in addition, voters and poll workers must be able to use them effectively. There are some special difficulties in the design of usable and accessible voting systems:

The voting task itself can be fairly complex; the voter may have to navigate an electronic ballot, choose multiple candidates in a single race or decide on abstrusely-worded referenda.

Voting is performed infrequently, so learning and familiarity are lower than for more frequent tasks, such as use of an ATM.

Jurisdictions may change voting equipment, thus obviating whatever familiarity the voter might have acquired.

Once the voting session has been completed by the voter, there is never a chance for later correction.

Voting must be accessible to all eligible citizens, whatever their age, physical abilities, language skills, or experience with technology.

The challenge, then, is to provide a voting system and voting environment that all voters can use comfortably, efficiently, and with justified confidence that they have cast their votes correctly. The requirements within this section are intended to serve that goal.

Although there are many detailed requirements, three broad principles motivate this section on human factors:

1. ALL ELIGIBLE AND POTENTIALLY ELIGIBLE VOTERS SHALL HAVE ACCESS TO THE VOTING PROCESS WITHOUT DISCRIMINATION.

The voting process shall allow eligible voters of whatever age, condition, or background to be able to go through the entire voting process with the same degree of independence, privacy, and confidence, insofar as technology will allow. Note that the voting process includes access to the polling place, instructions on how to vote, initiating the voting session, choosing candidates, getting help as needed, review of the ballot, VVPAT, and final submission of the ballot.

2. EACH CAST BALLOT SHALL CAPTURE THE INTENT OF THE VOTER WHO CAST THAT BALLOT.

1 Voters have the right to have the ballot presented to them in a manner that is clear and
2 usable. Voters should encounter no difficulty or confusion in recording their choices.

3 4 3. THE VOTING PROCESS SHALL PRESERVE THE SECRECY OF THE BALLOT.

5
6 The voting process shall preclude anyone else from determining the content of a voter's
7 ballot, with or without the voter's cooperation. If such a determination is made against the
8 wishes of the voter, then his or her privacy has been violated. The process must also
9 preclude the voter from disclosing the content of the ballot to anyone else.

10
11 All the requirements within section 2.2.7 have the purpose of improving the quality of
12 interaction between voters and voting systems.

- 13
- 14 • Requirements that are likely to be relevant only to those with some disability
15 are listed under 2.2.7.1, although they may also assist those not usually
16 described as having a disability, e.g. voters with poor eyesight or somewhat
17 limited dexterity.
 - 18
 - 19 • Requirements that are likely to be relevant only to those with limited English
20 proficiency are listed in 2.2.7.2.
 - 21
 - 22 • Finally, requirements for general usability make up section 2.2.7.3 and those
23 for privacy, section 2.2.7.4.

24
25 Certain abbreviations and terms are used extensively throughout section 2.2.7:

- 26
- 27 • CIF: Common Industry Format: Refers to the format described in
28 ANSI/INCITS 354-2001 "Common Industry Format (CIF) for Usability Test
29 Reports".
 - 30
 - 31 • Acc-VS: Accessible Voting Station - the voting station equipped for
32 individuals with disabilities referred to in HAVA 301 (a)(3)(B).
 - 33
 - 34 • ATI: Audio-Tactile Interface - a voter interface designed so as not to require
35 visual reading of a ballot. Audio is used to convey information to the voter and
36 sensitive tactile controls allow the voter to convey information to the voting
37 system.
 - 38
 - 39 • ALVS: Alternative Language Voting Station - a voting station designed to be
40 usable by voters who have limited English proficiency.

41
42 This section also uses common terms as defined in the updated Glossary. Note in
43 particular, the distinctions among "voting system," "voting station," and "voting process."
44

1 **2.2.7.1 The voting process shall be accessible to voters with disabilities.**
2 **As a minimum, every polling place shall have at least one voting**
3 **station equipped for individuals with disabilities, as provided in**
4 **HAVA 301 (a)(3)(B). A station so equipped is referred to herein as**
5 **an accessible voting station (Acc-VS).**
6

7 HAVA section 301 (a)(3) reads in part:
8

9 "ACCESSIBILITY FOR INDIVIDUALS WITH DISABILITIES.--The voting system
10 shall—

11 (A) be accessible for individuals with disabilities, including nonvisual accessibility for
12 the blind and visually impaired, in a manner that provides the same opportunity for
13 access and participation (including privacy and independence) as for other voters;

14 (B) satisfy the requirement of subparagraph (A) through the use of at least one direct
15 recording electronic voting system or other voting system equipped for individuals with
16 disabilities at each polling place;"
17

18 The requirements within section 2.2.7.1 are intended to address this mandate. Ideally
19 every voter would be able to vote independently and privately. As a practical matter,
20 there may be a small number of voters whose disabilities are so severe that they will need
21 personal assistance. Nonetheless, the requirements of this section are meant to make the
22 voting system directly accessible to as many voters as possible.
23

24 Note that this section does not replace requirements of other sections, but adds to them.
25 In particular, the requirements of section 2.2.7.3 on Usability apply either to all voting
26 stations or, in some cases, to all DRE voting stations; many of these requirements support
27 accessibility as well as general usability.
28

29 The outline for Section 2.2.7.1 is:

- 30 2.2.7.1 Accessibility
- 31 2.2.7.1.1 Voters with Disabilities - General
- 32 2.2.7.1.2 Vision
- 33 2.2.7.1.2.1 Partial Vision
- 34 2.2.7.1.2.2 Blind
- 35 2.2.7.1.3 Dexterity
- 36 2.2.7.1.4 Mobility
- 37 2.2.7.1.5 Hearing
- 38 2.2.7.1.6 Speech
- 39 2.2.7.1.7 Cognitive
- 40

41 Certain accessibility features that are likely to be useful to a wide range of voters are
42 required on all voting stations, not just the Acc-VS. Finally, note that the Acc-VS is not
43 necessarily a full-fledged DRE; for instance, an implementation may provide an ATI that
44 generates an optiscan ballot.
45

1 **2.2.7.1.1** The voting process shall incorporate features that are applicable
2 to several types of disability.
3

4 Discussion: These features span the disability categories within
5 requirement # 2.2.7.1 (e.g. vision, dexterity).

6 **2.2.7.1.1.1** When the provision of accessibility involves an
7 alternative format for ballot presentation, then all the other
8 information presented to voters in the case of non-disabled English-
9 literate voters (including instructions, warnings, messages, and
10 ballot choices) shall also be presented in that alternative format.

11 Responsible Entity: voting system vendor, voting officials
12 Process: voting
13

14 Discussion: This is a general principle to be followed for any
15 alternative format presentation. Two particular cases, 1) audio
16 formats and 2) non-English formats, are the subject of specific
17 requirements in later sections.
18

19 **2.2.7.1.1.2** An Acc-VS shall provide direct accessibility such that
20 voters' personal assistive devices are not required for voting.

21 Responsible Entity: voting system vendor
22 Process: voting
23

24 Discussion: Voters are not to be obliged to supply any special
25 equipment in order to vote. This requirement does not preclude the
26 Acc-VS from providing interfaces to assistive technology.
27

28 **2.2.7.1.1.3** When the primary means of voter identification or
29 authentication uses biometric measures that require a voter to
30 possess particular biological characteristics, the voting process
31 shall provide a secondary means that does not depend on those
32 characteristics.

33 Responsible Entity: voting system vendor, voting official
34 Process: voting
35

36 Discussion: For example, if fingerprints were used for identification,
37 there would have to be another mechanism for voters without usable
38 fingerprints.
39

40 **2.2.7.1.1.4** Polling places shall conform to the appropriate
41 guidelines of the Americans with Disabilities Act (ADA) of 1990 and
42 of the Architectural Barriers Act (ABA) of 1968.

Responsible Entity: voting officials
Process: pre-voting/voting

Discussion: This requirement does not stem from HAVA, but rather is a reminder of other legal obligations. For more details, see <http://www.access-board.gov/ada-aba.htm> and <http://www.usdoj.gov/crt/ada/votingck.htm>.

2.2.7.1.2 The voting process shall be accessible to voters with visual disabilities.

Discussion: Note that all aspects of the process are to be accessible, not just the voting station.

2.2.7.1.2.1 The Acc-VS shall be accessible to voters with partial vision.

2.2.7.1.2.1.1 The vendor shall conduct summative usability tests on the Acc-VS using partially sighted subjects and shall report the test results to the appropriate VSTL according to the Common Industry Format (CIF).

Responsible Entity: voting system vendor
Process: voting

Discussion: This requirement is meant to ensure that Acc-VS designers conduct some realistic usability tests on the final product. For now, it is purely a documentation requirement. Future versions of the VVSG may include specific performance benchmarks.

2.2.7.1.2.1.2 The Acc-VS and any voting station with an electronic image display shall be capable of showing all information in at least two font sizes, a) 3.0-4.0 mm and b) 6.3-9.0 mm, under control of the voter.

Responsible Entity: voting system vendor
Process: voting

Discussion: While larger font sizes may assist most voters with poor vision, certain disabilities such as tunnel vision are best addressed by smaller font sizes.

2.2.7.1.2.1.3 All voting stations using paper ballots should make provisions for voters with poor reading vision.

Responsible Entity: voting system vendor
Process: voting

Discussion: Possible solutions include: 1) providing paper ballots in at least two font sizes, 3.0-4.0mm and 6.3-9.0mm and 2) providing a magnifying device.

2.2.7.1.2.1.4 An Acc-VS and any voting station with a black and white electronic image display shall be capable of showing all information in high contrast either by default or under the control of the voter. High contrast is a figure-to-ground ambient contrast ratio for text and informational graphics of at least 6:1.

Responsible Entity: voting system vendor
Process: voting

2.2.7.1.2.1.5 An Acc-VS with a color-only electronic image display shall allow the voter to adjust the figure-to-ground ambient contrast ratio. The minimum value available shall be in the range 2.7-3.3 : 1. The maximum value available shall be in the range 5.7-6.3 : 1.

Responsible Entity: voting system vendor
Process: voting

2.2.7.1.2.1.6 An Acc-VS with a color-only electronic image display shall allow the voter to adjust the red, green, and blue components of the foreground and background color.

Responsible Entity: voting system vendor
Process: voting

2.2.7.1.2.1.7 On all voting stations, the default color coding shall maximize correct perception by voters and operators with color blindness.

Responsible Entity: voting system vendor
Process: voting

2.2.7.1.2.1.8 On all voting stations, color coding shall not be used as the sole means of conveying information, indicating

an action, prompting a response, or distinguishing a visual element.

Responsible Entity: voting system vendor
Process: voting

Discussion: This implies that although color can be used for emphasis, some other non-color mode must also be used to convey the information, such as a shape or text style. For example, red can be enclosed in an octagon shape.

2.2.7.1.2.1.9 Any voting station using an electronic image display should also provide synchronized audio output to convey the same information as that on the screen.

Responsible Entity: voting system vendor
Process: voting

Discussion: Synchronized presentation of information in both visual and aural modes is a recommendation in this version of the VVSG, but it is anticipated that this will become a requirement in future versions.

2.2.7.1.2.1.10 Buttons and controls on all voting stations should be distinguishable by both shape and color.

Responsible Entity: voting system vendor
Process: voting

Discussion: The redundant cues have been found to be helpful to those with partial vision.

2.2.7.1.2.2 The Acc-VS shall be accessible to voters who are blind.

Discussion: Of course, many of the features under this requirement are also useful for voters with partial vision (see requirement # 2.2.7.1.2.1) and for voters who cannot read English for other reasons (see requirement # 2.2.7.2).

2.2.7.1.2.2.1 The vendor shall conduct summative usability tests on the Acc-VS using subjects who are blind and shall report the test results to the appropriate VSTL according to the Common Industry Format (CIF).

Responsible Entity: voting system vendor
Process: voting

Discussion: This requirement is meant to ensure that Acc-VS designers conduct some realistic usability tests on the final product. For now, it is purely a documentation requirement. Future versions of the VVSG may include specific performance benchmarks.

2.2.7.1.2.2.2 The Acc-VS shall provide an audio-tactile interface (ATI) that supports the full functionality of a normal ballot interface, as specified in section 2.4.

Responsible Entity: voting system vendor
Process: voting

Discussion: Note the necessity of both audio output and tactilely discernible controls for voter input. Full functionality includes at least:

- a) Instructions and feedback on initial activation of the ballot (such as insertion of a smart card), if this is normally performed by the voter on comparable voting stations,
- b) Instructions and feedback to the voter on how to operate the Acc-VS, including settings and options (e.g. volume control, repetition),
- c) Instructions and feedback for navigation of the ballot,
- d) Instructions and feedback for voter selections in races and referenda, including write-in candidates,
- e) Instructions and feedback on confirming and changing selections,
- f) Instructions and feedback on final submission of ballot.

2.2.7.1.2.2.2.1 *The ATI of the Acc-VS shall provide the same capabilities to vote and cast a ballot as are provided by the non-accessible stations or by the visual interface of the Acc-VS. Therefore, functional features that exceed the requirements of section 2.4 must be provided on a non-discriminatory basis.*

Responsible Entity: voting system vendor
Process: voting

Discussion: For example, if a "normal" ballot supports voting a straight party ticket and then changing the choice in a single race, so must the ATI. This requirement is a special case of the more general requirement # 2.2.7.1.1.1.

2.2.7.1.2.2.2.1.1 The ATI shall allow the voter to have any information provided by the system repeated.

Responsible Entity: voting system vendor
Process: voting

2.2.7.1.2.2.2.2 *The ATI shall allow the voter to pause and resume the audio presentation.*

Responsible Entity: voting system vendor
Process: voting

2.2.7.1.2.2.2.3 *The ATI shall allow the voter to skip to the next contest.*

Responsible Entity: voting system vendor
Process: voting

Discussion: This is analogous to the ability of sighted voters to move on to the next race once they have made a selection or to abstain from voting on a contest.

2.2.7.1.2.2.2.4 *The ATI should allow the voter to skip over the reading of a referendum so as to be able to vote on it immediately.*

Responsible Entity: voting system vendor
Process: voting

Discussion: This is analogous to the ability of sighted voters to skip over the wording of a referendum on which they have already made a decision prior to the voting session (e.g. "Vote yes on proposition #123"). It is anticipated that this recommendation will become a requirement in future versions of the VVSG.

2.2.7.1.2.2.3 All voting stations that provide audio presentation of the ballot shall conform to the following sub-requirements.

Discussion: These requirements apply to all audio output, not just to the ATI of an Acc-VS.

1 **2.2.7.1.2.2.3.1** *The ATI shall provide its audio signal through an*
2 *industry standard connector for private listening using a 3.5mm*
3 *stereo headphone jack to allow voters to use their own audio*
4 *assistive devices.*
5

6 Responsible Entity: voting system vendor
7 Process: voting
8

9 **2.2.7.1.2.2.3.2** *When a voting station utilizes a telephone style*
10 *handset/headset to provide audio information, it shall provide a*
11 *wireless coupling for assistive hearing devices so as to provide*
12 *access to that information for voters with partial hearing.*
13

14 Responsible Entity: voting system vendor
15 Process: voting
16

17 **2.2.7.1.2.2.3.3** *No voting station shall cause electromagnetic*
18 *interference with assistive hearing devices that would substantially*
19 *degrade the performance of those devices.*
20

21 Responsible Entity: voting system vendor
22 Process: voting
23

24 Discussion: "Hearing devices" includes hearing aids and
25 cochlear implants.
26

27 **2.2.7.1.2.2.3.4** *A sanitized headphone or handset shall be made*
28 *available to each voter.*
29

30 Responsible Entity: voting system vendor, voting officials
31 Process: voting
32

33 Discussion: This requirement can be achieved in various ways,
34 including the use of "throwaway" headphones, or of sanitary
35 coverings.
36

37 **2.2.7.1.2.2.3.5** *The voting station shall set the initial volume for*
38 *each voter between 40 and 50 dB.*
39

40 Responsible Entity: voting system vendor
41 Process: voting
42

Discussion: A voter does not "inherit" the volume as set by the previous user of the voting station.

2.2.7.1.2.2.3.6 *The voting station shall provide a volume control with an adjustable amplification from a minimum of 20dB up to a maximum of 105 dB, in increments no greater than 20dB.*

Responsible Entity: voting system vendor
Process: voting

2.2.7.1.2.2.3.7 *The audio system shall be able to reproduce frequencies over the audible speech range of 315 Hz to 3150 Hz.*

Responsible Entity: voting system vendor
Process: voting

2.2.7.1.2.2.3.8 *The audio system should provide information via recorded human speech, rather than synthesized speech.*

Responsible Entity: voting system vendor
Process: voting

Discussion: Most users prefer real speech over synthesized speech.

2.2.7.1.2.2.3.9 *The audio system should allow voters to control, within reasonable limits, the rate of speech.*

Responsible Entity: voting system vendor
Process: voting

Discussion: Many blind voters are accustomed to interacting with accelerated speech.

2.2.7.1.2.2.4 If the normal procedure is to have voters initialize the activation of the ballot, the Acc-VS shall provide features that enable voters who are blind to perform this activation.

Responsible Entity: voting system vendor
Process: voting

Discussion: For example, smart cards might provide tactile cues so as to allow correct insertion.

2.2.7.1.2.2.5 If the normal procedure is for voters to submit their own ballots, then the voting process should provide features that enable voters who are blind to perform this submission.

Responsible Entity: voting system vendor, voting officials
Process: voting

Discussion: For example, if voters normally feed their own optiscan ballots into a reader, blind voters should also be able to do so.

2.2.7.1.2.2.6 If the normal procedure includes VVPAT, the Acc-VS should provide features that enable voters who are blind to perform this verification.

Responsible Entity: voting system vendor
Process: voting

Discussion: For example, the Acc-VS might provide an automated reader for the paper record that converts the contents of the paper into audio output. It is anticipated that this recommendation will become a requirement in future versions of the VVSG.

2.2.7.1.2.2.7 All mechanically operated controls or keys on an Acc-VS shall be tactilely discernible without activating those controls or keys.

Responsible Entity: voting system vendor
Process: voting

2.2.7.1.2.2.8 On an Acc-VS, the status of all locking or toggle controls or keys (such as the "shift" key) shall be visually discernible, and discernible either through touch or sound.

Responsible Entity: voting system vendor
Process: voting

2.2.7.1.3 The voting process shall be accessible to voters who lack fine motor control or the use of their hands.

2.2.7.1.3.1 The vendor shall conduct summative usability tests on the Acc-VS with subjects lacking fine motor control and shall report the test results to the appropriate VSTL according to the Common Industry Format (CIF).

Responsible Entity: voting system vendor

Process: voting

Discussion: This requirement is meant to ensure that Acc-VS designers conduct some realistic usability tests on the final product. For now, it is purely a documentation requirement. Future versions of the VVSG may include specific performance benchmarks.

2.2.7.1.3.1.1 All keys and controls on the Acc-VS shall be operable with one hand and shall not require tight grasping, pinching, or twisting of the wrist. The force required to activate controls and keys shall be no greater 5 lbs. (22.2 N).

Responsible Entity: voting system vendor

Process: voting

Discussion: Controls must be operable without excessive force.

2.2.7.1.3.2 The Acc-VS controls shall not require direct bodily contact or for the body to be part of any electrical circuit.

Responsible Entity: voting system vendor

Process: voting

Discussion: This requirement ensures that controls are operable by individuals using prosthetic devices.

2.2.7.1.3.3 The Acc-VS should provide a “sip and puff” mechanism to enable non-manual input functionally equivalent to tactile input.

Responsible Entity: voting system vendor

1 Process: voting

2
3 Discussion: This recommendation ensures that the Acc-VS is operable
4 by individuals who do not have the use of their hands. All the
5 functionality of the Acc-VS (e.g. straight party voting, write-in
6 candidates) that is available through the other forms of input, such as
7 tactile, must also be available through the “sip and puff,” if provided.
8

9 **2.2.7.1.4** The voting process shall be accessible to voters who use
10 mobility aids, including wheelchairs.
11

12 **2.2.7.1.4.1.1** The Acc-VS shall provide a clear floor space of
13 30 inches (762 mm) minimum by 48 inches (1219 mm)
14 minimum for a stationary mobility aid. The clear floor space
15 shall be level with no slope exceeding 1:48 and positioned
16 for a forward approach or a parallel approach.
17

18 Responsible Entity: voting system vendor, voting officials
19 Process: pre-voting/voting
20

21 **2.2.7.1.4.2** All controls, keys, audio jacks and any other part of the
22 Acc-VS necessary for the voter to operate the voting system shall
23 be within the reach regions as specified under the following sub-
24 requirements.
25

26 Responsible Entity: voting system vendor, voting officials
27 Process: pre-voting/voting
28

29 Discussion: All dimensions are given in inches. To convert to
30 centimeters, multiply by 2.54. Note that these sub-requirements
31 have meaningful application mainly to controls in a fixed location.
32 A hand-held tethered control panel is another acceptable way of
33 providing reachable controls. All the sub-requirements inherit the
34 "responsible entity" and "process" properties.
35

36 **2.2.7.1.4.2.1** If the Acc-VS has a forward approach with no
37 forward reach obstruction then the maximum high reach
38 shall be 48 inches and the minimum low reach shall be 15
39 inches. See Figure 2.2.7.1-1.
40

2.2.7.1.4.2.2 If the Acc-VS has a forward approach with a forward reach obstruction, the following sub-requirements apply. See Figure 2.2.7.1-2.

2.2.7.1.4.2.2.1 *The forward obstruction shall be no greater than 25 inches in depth, its top no higher than 34 inches and its bottom surface no lower than 27 inches.*

2.2.7.1.4.2.2.2 *If the obstruction is no more than 20 inches in depth, then the maximum high reach shall be 48 inches, otherwise it shall be 44 inches.*

2.2.7.1.4.2.2.3 *Clear floor space under the obstruction shall be provided as specified in the following sub-requirements. For these requirements: a) "toe depth" is defined as the minimum depth of clearance under the obstruction between 0 and 9 inches above the finished floor, b) "knee depth" is defined as the (possibly variable) depth of clearance between 9 and 27 inches above the finished floor and c) "reference depth" is defined as the obstruction depth or 17 inches, whichever is greater.*

2.2.7.1.4.2.2.3.1 The width of the toe clearance and knee clearance shall be at least 30 inches.

2.2.7.1.4.2.2.3.2 The minimum toe depth shall be the reference depth.

Discussion: In other words, the toe must be able to go at least as far under the obstruction as the reach distance over the obstruction.

2.2.7.1.4.2.2.3.3 The minimum knee depth shall depend on the height above the floor according to the formula:
reference depth - ((height + 27) / 6).

Discussion: For instance, if the reach distance over the obstruction is 20 inches, then the reference depth is also 20 inches and the knee depth at a height of 9 inches must be at least 14 inches, and at 27 inches of height at least 11 inches.

2.2.7.1.4.2.3 If the Acc-VS has a parallel approach with no side reach obstruction then the maximum high reach shall be 48 inches and the minimum low reach shall be 15 inches. See Figure 2.2.7.1-3.

2.2.7.1.4.2.4 If the Acc-VS has a parallel approach with a side reach obstruction, the following sub-requirements apply. See Figure 2.2.7.1-4.

2.2.7.1.4.2.4.1 *The side obstruction shall be no greater than 24 inches in depth and its top no higher than 34 inches.*

Responsible Entity: voting system vendor, voting officials

2.2.7.1.4.2.4.2 *If the obstruction is no more than 10 inches in depth, then the maximum high reach shall be 48 inches, otherwise it shall be 44 inches.*

Discussion: Since this is a parallel approach, no clearance under the obstruction is required.

2.2.7.1.4.2.5 All labels, displays, controls, keys, audio jacks and any other part of the Acc-VS necessary for the voter to operate the voting system shall be easily legible and visible to a voter in a wheelchair with normal eyesight (no worse than 20/40, corrected) who is in an appropriate position and orientation with respect to the Acc-VS.

Responsible Entity: voting system vendor, voting officials
Process: pre-voting/voting

Discussion: There are a number of factors that could make relevant parts of the Acc-VS difficult to see: small lettering, controls and labels tilted at an awkward angle from the voter's viewpoint, glare from overhead lighting, etc.

2.2.7.1.5 The voting process shall be accessible to voters with hearing disabilities.

2.2.7.1.5.1.1 The Acc-VS shall incorporate the features listed under requirement # 2.2.7.1.2.2.3 (audio presentation) to provide accessibility to voters with hearing disabilities.

1 Responsible Entity: voting system vendor, voting officials
2 Process: voting
3

4 Discussion: Note especially the requirements for volume
5 initialization and control.

6 **2.2.7.1.5.1.2** If a voting station provides sound cues as a
7 method to alert the voter, the tone shall be accompanied by
8 a visual cue.
9

10 Responsible Entity: voting system vendor
11 Process: voting
12

13 Discussion: For instance, the station might beep if the voter
14 attempts to overvote. If so, there would have to be an
15 equivalent visual cue, such as the appearance of an icon, or a
16 blinking element.

17 **2.2.7.1.6** The voting process shall be accessible to voters with speech
18 disabilities.
19

20 **2.2.7.1.6.1** No voting station shall require voter speech for its
21 operation.
22

23 Responsible Entity: voting system vendor
24 Process: voting
25

26 Discussion: This does not preclude a voting station from offering
27 speech input as an option, but speech must not be the only means of
28 input.
29

30 **2.2.7.1.7** The voting process shall be accessible to voters with cognitive
31 disabilities.
32

33 Responsible Entity: voting system vendors, voting officials
34 Process: voting
35

36 Discussion: At present there are no design features specifically aimed
37 at helping those with cognitive disabilities. Clause 1.2.1.9, the
38 synchronization of audio with the screen in a DRE is helpful for some
39 cognitive disabilities such as dyslexia.
40
41
42

Figures for Accessibility

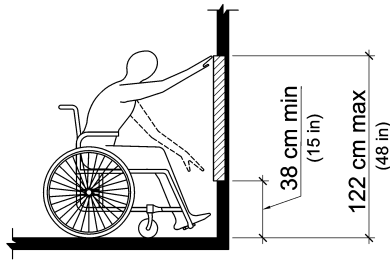


Figure 2.2.7.1-1
Unobstructed forward reach

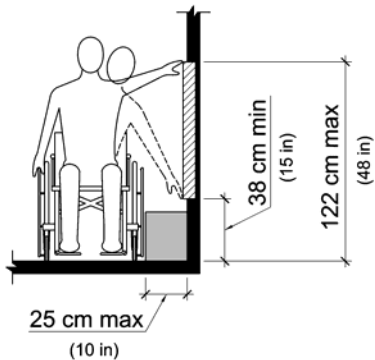


Figure 2.2.7.1-3
Unobstructed side reach with an allowable obstruction less than 25 cm (10 inches) deep.

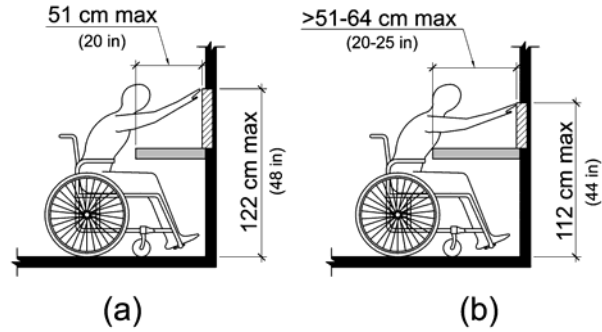


Figure 2.2.7.1-2
Obstructed forward reach
(a) for an obstruction depth of up to 51 cm (20 inches)
(b) for an obstruction depth of up to 54 cm (25 inches)

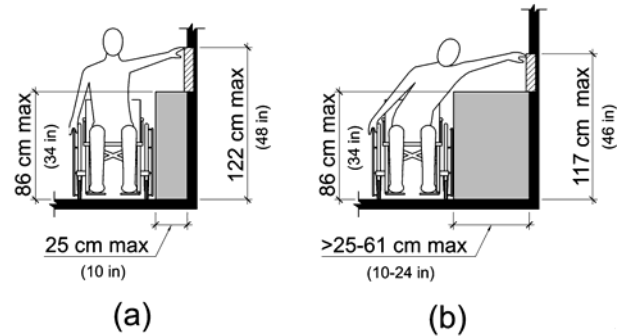


Figure 2.2.7.1-4
Obstructed side reach
(a) for an obstruction depth of up to 25 cm (10 inches)
(b) for an obstruction depth of up to 61 cm (24 inches)

1 **2.2.7.2 The voting process shall be accessible to voters who are not fully**
2 **literate in English. This requirement may be satisfied by**
3 **providing voting stations in a polling place that accommodate**
4 **those without a full command of English. See HAVA 301 (a)(4)**
5 **and 241 (b)(5). Such a facility is referred to herein as an**
6 **alternative language voting station (ALVS).**

7
8 HAVA section 301 (a)(4) reads:
9

10 “ALTERNATIVE LANGUAGE ACCESSIBILITY.--The voting system shall provide
11 alternative language accessibility pursuant to the requirements of section 203 of the
12 Voting Rights Act of 1965 (42 U.S.C. 1973aa-1a).”
13

14 The requirements within section 2.2.7.2 are intended to address this mandate. Ideally
15 every voter would be able to vote independently and privately, regardless of language.
16 As a practical matter, alternative language access is mandated under the Voting Rights
17 Act of 1975, subject to certain thresholds, e.g. if the language group exceeds 5% of the
18 voting age citizens.
19

20 Note that the provision of an audio interface for people with visual disabilities as
21 described in section 2.2.7.1 may also assist voters who speak English, but are unable to
22 read it.
23

24 The outline for section 2.2.7.2 is:
25

26 2.2.7.2. Alternative Languages
27 2.2.7.2.1 Complete Information
28 2.2.7.2.2 Spelling of Names
29 2.2.7.2.3 Literate Voters
30 2.2.7.2.4 Illiterate Voters

31 **2.2.7.2.1 All the information presented in the normal case of English-**
32 **literate voters (including instructions, warnings, messages, and ballot**
33 **choices) shall also be presented by the ALVS, whether the language is**
34 **written or spoken.**

35
36 Responsible Entity: voting system vendor
37 Process: voting
38

39 Discussion: This is in keeping with general requirement # 2.2.7.1.1.1.

40 **2.2.7.2.2 Regardless of the language, candidate names shall be displayed**
41 **or pronounced in English on all ballots. For written languages that do not**
42 **use Roman characters (e.g. Chinese, Japanese, Korean, Arabic), the**
43 **ballot shall include transliteration of candidate names into the relevant**
44 **language.**

Responsible Entity: voting system vendor, voting officials
Process: voting

2.2.7.2.3 For literate voters, the ALVS shall provide printed or displayed instructions, messages, and ballots in their preferred language, consistent with state and Federal law.

Responsible Entity: voting system vendor
Process: voting

2.2.7.2.3.1 The vendor shall conduct summative usability tests on the ALVS with literate subjects who neither speak nor read English and shall report the test results according to the Common Industry Format (CIF).

Responsible Entity: voting system vendor
Process: voting

Discussion: This requirement is meant to ensure that Acc-VS designers conduct some realistic usability tests on the final product. For now, it is purely a documentation requirement. Future versions of the VVSG may include specific performance benchmarks.

2.2.7.2.4 For illiterate voters, the ALVS shall provide spoken instructions and ballots in the preferred language of the voter, consistent with state and Federal law. The requirements and sub-requirements of # 2.2.7.1.2.2.2 (Acc-VS/ATI) shall apply to this mode of interaction.

Responsible Entity: voting system vendor
Process: voting

Discussion: Note that some languages have no widely accepted written form.

2.2.7.3 The voting process shall provide a high level of usability to the voters. Accordingly, voters shall be able to negotiate the process effectively, efficiently, and comfortably.

The first Voting System Standards codified in HAVA relate to the interaction between the voter and the voting system. HAVA section 301 begins:

"SEC. 301. VOTING SYSTEMS STANDARDS.

1 a. Requirements.--Each voting system used in an election for Federal office shall meet
2 the following requirements:
3 1. In general.--
4
5 A. Except as provided in subparagraph (B), the voting system (including any lever voting
6 system, optical scanning voting system, or direct recording electronic system) shall--
7
8 i. Permit the voter to verify (in a private and independent manner) the votes selected by
9 the voter on the ballot before the ballot is cast and counted;
10
11 ii. Provide the voter with the opportunity (in a private and independent manner) to change
12 the ballot or correct any error before the ballot is cast and counted (including the
13 opportunity to correct the error through the issuance of a replacement ballot if the voter
14 was otherwise unable to change the ballot or correct any error); and
15
16 iii. If the voter selects votes for more than one candidate for a single office--
17
18 I. Notify the voter that the voter has selected more than one candidate for a single office
19 on the ballot;
20
21 II. Notify the voter before the ballot is cast and counted of the effect of casting multiple
22 votes for the office; and
23
24 III. Provide the voter with the opportunity to correct the ballot before the ballot is cast
25 and counted.
26
27 B. A State or jurisdiction that uses a paper ballot voting system, a punch card voting
28 system, or a central count voting system (including mail-in absentee ballots and mail-in
29 ballots), may meet the requirements of subparagraph (A)(iii) by--
30
31 i. Establishing a voter education program specific to that voting system that notifies each
32 voter of the effect of casting multiple votes for an office; and
33
34 ii. Providing the voter with instructions on how to correct the ballot before it is cast and
35 counted (including instructions on how to correct the error through the issuance of a
36 replacement ballot if the voter was otherwise unable to change the ballot or correct any
37 error).
38
39 C. The voting system shall ensure that any notification required under this paragraph
40 preserves the privacy of the voter and the confidentiality of the ballot."
41
42 The requirements of this section supplement these basic HAVA mandates and also
43 HAVA's support for improved usability (see section 243 and section 221 (e)(2)(D)).
44

45 VOTING AND USABILITY

Usability is defined generally as a measure of the effectiveness, efficiency, and satisfaction achieved by a specified set of users with a given product in the performance of specified tasks. In the context of voting, the primary users are the voters (but also poll workers), the product is the voting system, and the task is the correct representation of one's choices in the election. Additional requirements for task performance are independence and privacy: the voter should normally be able to complete the voting task without assistance from others (although the voting system itself may offer help), and the voter's choices should be private (see section 2.2.7.4). Aside from its intrinsic undesirability, lack of independence or privacy may adversely affect effectiveness (e.g. by possibly inhibiting the voter's free choice) and efficiency (e.g. by slowing down the process).

METHODOLOGY FOR REQUIREMENTS

It is the intention of the TGDC that in forthcoming versions of the VVSG, usability will be addressed by high-level performance-based requirements. That is, the requirements will directly address metrics for effectiveness (e.g. correct capture of voters' intentions), efficiency (e.g. time taken to vote), and satisfaction. Until the supporting research is completed, however, the contents of this subsection are limited to a somewhat basic set of widely accepted design requirements and lower-level performance requirements. The reasons for this approach are:

These are to serve as interim requirements, pending the issuance of high-level performance requirements.

The actual benefit of numerous detailed design guidelines is difficult to prove or measure.

The technical complexity and costs of a large set of detailed requirements may not be justified.

Guidelines that are difficult to test because of insufficient specificity have been omitted.

This is not to say that an extensive set of design guidelines is without value. But we wish to distinguish between good advice to be considered by developers and strict requirements that will be enforced by a regime of formal testing. For more detail on the issue of design vs. performance standards, please see sections 2.3 and 6.1 et al of NIST Special Publication 500-256: Improving the Usability and Accessibility of Voting Systems and Products (<http://vote.nist.gov/Final%20Human%20Factors%20Report%20%2005-04.pdf>).

GENERAL ISSUES FOR THE USABILITY REQUIREMENTS

As mentioned in section 2.2.7.1, many of the guidelines in this section enhance accessibility as well as general usability.

1
2 The scope of usability includes the entire voting process, although the emphasis herein is
3 on the interface between the voter and the voting station.
4

5 The requirements in this sub-section generally assume a visual-tactile interface, but also
6 see requirements in sections 2.2.7.1 and 2.2.7.2 for alternative formats, including audio.
7

8 The outline for section 2.2.7.3 is:
9

10 2.2.7.3. Usability
11 2.2.7.3.1 Usability Testing by Vendor
12 2.2.7.3.2 Functional Capabilities
13 2.2.7.3.3 Cognitive Issues
14 2.2.7.3.4 Perceptual Issues
15 2.2.7.3.5 Interaction Issues
16

17 Discussion: Among the "bottom-line" metrics for usability are:

18 -- low error rate for marking the ballot (the voter's intention is correctly conveyed to and
19 represented within the voting system)
20 -- efficient operation (time required to vote is not excessive)
21 -- satisfaction (voter experience is safe, comfortable, free of stress, and instills
22 confidence)
23

24 These criteria define the core of good voting system usability. The purpose of the detailed
25 requirements listed below is to help voting systems meet the core criteria.
26

27 **2.2.7.3.1** The vendor shall conduct summative usability tests on the voting
28 system using subjects representative of the general population and shall
29 report the test results to the appropriate VSTL according to the Common
30 Industry Format (CIF).
31

32 Responsible Entity: voting system vendor
33 Process: voting
34

35 Discussion: This requirement is meant to ensure that designers conduct
36 some realistic usability tests on the final product. For now, it is purely
37 a documentation requirement. Future versions of the VVSG may
38 include specific performance benchmarks.
39

40 **2.2.7.3.2** The voting process shall provide certain functional capabilities to
41 support voter usability.
42

2.2.7.3.2.1 As mandated by HAVA 301 (a)(1)(A), the voting process shall allow the voter to review his or her completed ballot before final submission in order to verify that it correctly represents the intended vote. Further, the process shall provide a means by which the voter can correct the ballot if mistakes are detected.

Responsible Entity: voting system vendor, voting officials
Process: voting

Discussion: Note that this review and correction may be achieved by procedural means (e.g. in the case of paper ballots), as well as technical. This requirement is a brief paraphrase of the HAVA language but of course the statutory language is determinative.

2.2.7.3.2.2 As mandated by HAVA 301 (a)(1)(A), the voting process shall notify the voter if he or she has attempted to vote for more candidates than the maximum permitted in a given race and shall provide the voter with the opportunity to correct the ballot before final submission.

Responsible Entity: voting system vendor, voting officials
Process: voting

Discussion: Note that this notification and correction may be achieved by procedural means (e.g. in the case of paper ballots), as well as technical. This requirement is a brief paraphrase of the HAVA language but of course the statutory language is determinative.

2.2.7.3.2.3 DRE voting stations shall allow the voter to change a vote within a race before advancing to the next race.

Responsible Entity: voting system vendor
Process: voting

Discussion: The point here is that voters using a DRE should not have to wait for the final ballot review in order to change a vote.

2.2.7.3.2.4 The voting process shall notify the voter if he or she has attempted to vote for fewer candidates than the maximum permitted in a given race and provide the voter with the opportunity to change the ballot before final submission. The process shall also notify the voter that such an "undervote" is permitted and shall accept a ballot if the voter so chooses.

Responsible Entity: voting system vendor, voting officials
Process: voting

Discussion: Note that this notification and correction may be achieved by procedural means (e.g. in the case of paper ballots), as well as technical.

2.2.7.3.2.5 DRE voting stations should provide navigation controls that allow the voter to advance to the next race or go back to the previous race before the completing a vote on the race or races currently being presented (whether visually or aurally).

Responsible Entity: voting system vendor
Process: voting

Discussion: For example, the voter should not be forced to proceed sequentially through all the races and/or candidates before going back to check the status of a previous race.

2.2.7.3.3 The voting process shall be designed to minimize cognitive difficulties for the voter.

2.2.7.3.3.1 Consistent with election law, the voting process shall not introduce any bias for or against any of the choices to be made by the voter. In both visual and aural formats, candidates and choices shall be presented in an equivalent manner.

Responsible Entity: voting system vendor, voting officials
Process: voting

Discussion: Certain differences in presentation are unavoidable, such as the order in which candidates are listed, and write-in candidates are inherently more difficult to vote for. But comparable characteristics such as font size or voice volume and speed must be the same for all choices.

2.2.7.3.3.2 The voting process shall enable and encourage voters to be well-prepared for the voting session.

2.2.7.3.3.2.1 Voters should have access to sample ballots and all relevant instructions before the voting session.

Responsible Entity: voting officials
Process: pre-voting

1 **2.2.7.3.3.2** Voters should have an opportunity to practice
2 voting before the actual voting session, especially for DRE
3 systems.
4

5 Responsible Entity: voting officials

6 Process: pre-voting
7

8 Discussion: For example, web-based support can provide
9 access to ballot information and instructions for operating the
10 voting station. Practice material and equipment may also be
11 provided at the polling place.
12

13 **2.2.7.3.3.3** The voting process shall provide clear instructions and
14 assistance so as to allow voters to successfully execute and cast
15 their ballots independently.
16

17 Discussion: Voters should not routinely need to ask for human
18 assistance.

19 **2.2.7.3.3.3.1** Voting stations should provide a means for the
20 voter to get help from the station at any time during the
21 voting session.
22

23 Responsible Entity: voting system vendor

24 Process: voting
25

26 Discussion: The voter should always be able to get help at the
27 station if confused. DRE voting stations may provide this
28 with a distinctive "help" button. Any type of voting station
29 may provide written instructions that are available and
30 separate from the ballot. Note special requirements for the
31 Acc-VS in # 2.2.7.1.2.2.2 (Acc-VS/ATI).
32

33 **2.2.7.3.3.3.2** The voting process shall provide human
34 assistance if requested by the voter.
35

36 Responsible Entity: voting officials

37 Process: voting
38

39 Discussion: The voter should always be able to get help from a
40 poll worker if desired.
41

1 **2.2.7.3.3.3** The voting station shall provide instructions for
2 all its valid operations.
3

4 Responsible Entity: voting system vendor
5 Process: voting
6

7 Discussion: If an operation is available to the voter, it must be
8 documented. Examples include how to change a vote, how to
9 navigate among races, how to cast a party-line vote, and how
10 to cast a write-in vote.
11

12 **2.2.7.3.3.4** The ballot shall be designed for maximum clarity and
13 comprehension.
14

15 **2.2.7.3.3.4.1** The voting station should not visually present a
16 single race spread over two pages or two columns.
17

18 Responsible Entity: voting system vendor, voting officials
19 Process: voting
20

21 Discussion: Such a visual separation poses the risk that the
22 voter will perceive the race as two races. Of course, if a race
23 has a very large number of candidates, it may be infeasible to
24 observe this guideline.
25

26 **2.2.7.3.3.4.2** The ballot shall clearly indicate the maximum
27 number of candidates for which one can vote within a single
28 race.
29

30 Responsible Entity: voting system vendor, voting officials
31 Process: voting
32

33 **2.2.7.3.3.4.3** There shall be a consistent relationship
34 between the name of a candidate and the mechanism used
35 to vote for that candidate.
36

37 Responsible Entity: voting system vendor, voting officials
38 Process: voting
39

40 Discussion: For example, if the response field where voters
41 indicate their selections is located to the left of a candidate's

name, then each response field shall be located to the left of the associated candidate's names.

2.2.7.3.3.5 Warnings and alerts issued by the voting station should clearly state the nature of the problem and the set of responses available to the voter. The warning should clearly state whether the voter has performed or attempted an invalid operation or whether the voting equipment itself has failed in some way.

Responsible Entity: voting system vendor
Process: voting

Discussion: In case of an equipment failure, the only action available to the voter might be to get assistance from a poll worker.

2.2.7.3.3.6 The use of color by the voting station should agree with common conventions: i) Green, blue or white is used for general information or as a normal status indicator; ii) Amber or yellow is used to indicate warnings or a marginal status; iii) Red is used to indicate error conditions or a problem requiring immediate attention.

Responsible Entity: voting system vendor
Process: voting

2.2.7.3.4 The voting process shall be designed to minimize perceptual difficulties for the voter.

2.2.7.3.4.1 No display screen of a voting station shall flicker with a frequency between 2 Hz and 55 Hz.

Responsible Entity: voting system vendor
Process: voting

Discussion: Aside from usability concerns, this requirement protects voters with epilepsy.

2.2.7.3.4.2 Any aspect of the voting station that is adjustable by the voter, including font size, color, contrast, and audio volume, shall automatically reset to a standard default value upon completion of that voter's session.

Responsible Entity: voting system vendor
Process: voting

Discussion: This implies that the voting station shall present the same initial appearance to every voter (excluding, of course, substantive differences in the ballot content due to residence or party of the voter).

2.2.7.3.4.3 If any aspect of a voting station is adjustable by the voter, there should be a mechanism to reset all such aspects to their default values.

Responsible Entity: voting system vendor
Process: voting

2.2.7.3.4.4 The minimum font size for all text intended for the voter during the voting session shall be 3.0mm (measured as the height of a capital letter).

Responsible Entity: voting system vendor
Process: voting

2.2.7.3.4.5 All text intended for the voter during the voting session should be presented in a sans-serif font.

Responsible Entity: voting system vendor
Process: voting

Discussion: Experimentation has shown that users prefer such a font and the legibility of serif and sans-serif fonts is equivalent.

2.2.7.3.4.6 The minimum figure-to-ground ambient contrast ratio for all text and informational graphics (including icons) intended for the voter shall be 3:1.

Responsible Entity: voting system vendor
Process: voting

2.2.7.3.5 The voting process shall be designed to minimize interaction difficulties for the voter.

2.2.7.3.5.1 Voting stations with electronic image displays shall not require page scrolling by the voter.

Responsible Entity: voting system vendor
Process: voting

Discussion: This is not an intuitive operation for those unfamiliar with the use of computers. Even those experienced with computers often do not notice a scroll bar and miss information below the page. DREs may require voters to move to the next or previous "page".

2.2.7.3.5.2 The voting station shall provide unambiguous feedback regarding the voter's selection, such as displaying a checkmark beside the selected option or conspicuously changing its appearance.

Responsible Entity: voting system vendor
Process: voting

2.2.7.3.5.3 If the voting station requires a response by a voter within a specific period of time, it shall issue an alert at least 20 seconds before this time period has expired and provide a means by which the voter may receive additional time.

Responsible Entity: voting system vendor
Process: voting

2.2.7.3.5.4 Input mechanisms shall be designed so as to minimize accidental activation (also, see requirement # 2.2.7.1.2.2.7 on tactile discernability).

2.2.7.3.5.4.1 On touch screens, the sensitive touch areas shall have a minimum height of 0.5 inches and minimum width of 0.7 inches. The vertical distance between the centers of adjacent areas shall be at least 0.6 inches, and the horizontal distance at least 0.8 inches.

Responsible Entity: voting system vendor
Process: voting

2.2.7.3.5.4.2 No key or control on a voting station shall have a repeat feature enabled.

Responsible Entity: voting system vendor
Process: voting

Discussion: This is to preclude accidental activation.

1 **2.2.7.4 The voting process shall preclude anyone else from determining the**
2 **content of a voter's ballot, with or without the voter's**
3 **cooperation.**

4
5 Voter privacy is strongly supported by HAVA - see sections 221 (e)(2)(C) and 301 (a)(1).
6 In this subsection, we address only privacy concerns in relation to human factors issues,
7 but not with respect to the processing of cast ballots.
8

9 Although elections in American history have sometimes been public (and certain "town-
10 hall" questions are still voted openly), the use of the secret ballot for political office is
11 now universal.

12 Privacy in this context, including the property of the voter being unable to disclose his or
13 her vote, ensures that the voter can make choices based solely on his or her own
14 preferences without intimidation or inhibition.
15

16 The outline for section 2.2.7.4 is:

- 17 2.2.7.4 Privacy
- 18 2.2.7.4.1 Privacy at the polling place
- 19 2.2.7.4.2 No preservation of alternative formats
- 20 2.2.7.4.3 Absentee Balloting
- 21
- 22
- 23

24 Discussion: Among other practices, this forbids the issuance of a receipt to the voter that
25 would provide proof to another how he or she voted.
26

27 **2.2.7.4.1 The voting station and polling place shall be configured so as to**
28 **prevent others from learning the contents of a voter's ballot.**
29

30 **2.2.7.4.1.1 The ballot and any input controls shall be visible only to**
31 **the voter during the voting session and ballot submission.**
32

33 Responsible Entity: voting system vendor, voting officials
34 Process: voting
35

36 Discussion: Voting officials should take into account such factors as
37 visual barriers, windows, permitted waiting areas for other voters, and
38 procedures for ballot submission when not performed at the voting
39 station, e.g. submission of optiscan ballots to a central reader.
40

41 **2.2.7.4.1.2 The audio interface shall be audible only to the voter.**
42

43 Responsible Entity: voting system vendor, voting officials

1 Process: voting

2
3 Discussion: Voters who are hard of hearing but need to use an audio
4 interface may also need to increase the volume of the audio. Such
5 situations require headphones with low sound leakage.
6

7 **2.2.7.4.1.3** As mandated by HAVA 301 (a)(1)(C), the voting system
8 shall notify the voter of an attempted overvote in a way that
9 preserves the privacy of the voter and the confidentiality of the
10 ballot.
11

12 Responsible Entity: voting system vendor, voting officials
13 Process: voting
14

15 Discussion: This requirement is a brief paraphrase of the HAVA
16 language but of course the statutory language is determinative.
17

18 **2.2.7.4.2** Voter anonymity shall be maintained for alternative format ballot
19 presentation.
20

21 **2.2.7.4.2.1** No information shall be kept within a non-paper-based
22 Cast Vote Record that identifies any accessibility feature(s) used by
23 a voter.
24

25 Responsible Entity: voting system vendor
26 Process: voting
27

28 Discussion: Large-print paper ballots unavoidably preserve such
29 information.
30

31 **2.2.7.4.2.1.1** No information shall be kept within a non-
32 paper-based Cast Vote Record that identifies any alternative
33 language feature(s) used by a voter.
34

35 Responsible Entity: voting system vendor
36 Process: voting
37

38 Discussion: Non-English paper ballots unavoidably preserve
39 such information.
40

1 **2.2.7.4.3** The procedures for absentee balloting shall enable the voter to
2 preserve privacy.
3

4 Responsible Entity: voting officials

5 Process: voting
6

7 Discussion: There is no practical means to prevent a voter from
8 revealing an absentee paper ballot to others. But the procedures should
9 ensure that if a voter chooses to maintain privacy, it is not violated at a
10 later stage, in particular when the ballot is received by voting officials.
11
12